

WHAT IS CLAIMED IS:

1. A bidirectional check valve for controlling movement of fluid, said bidirectional check valve comprising:

a valve body having at least an opening and a further opening therein and having a passage connecting said opening and said further opening;

5 a poppet disposed within said passage of said valve body and arranged such that at least a portion of an outer surface of said poppet and at least a portion of a wall of said passage of said valve body define at least one channel; said poppet having at least an opening therein in proximity to said opening in said valve body and a passage connecting to said opening in said poppet;

10 a spring coupled to said poppet and arranged to drive said poppet in a direction such that when fluid passing through said opening in said valve body exerts a force on said poppet that is less than said spring force, a further portion of said outer surface of said poppet contacts a further portion of said passage wall of said valve body and prevents said fluid from flowing from said opening in said valve body into said channel, and when said fluid exerts a force on said poppet
15 that is greater than said spring force, said poppet is directed away from said further portion of said passage wall and permits said fluid to flow from said opening in said valve body through said channel and to said further opening in said valve body;

a further poppet disposed within said passage formed in said first mentioned poppet and arranged such that at least a portion of an outer surface of said further poppet and at least a
20 portion of a passage wall of said poppet define at least one further channel; said outer surface of said further poppet having at least an opening therein that connects to a passage formed within

said further poppet; said passage within said further poppet connecting to a further opening in said further poppet that is in proximity to said opening in said poppet; and

a further spring coupled to said poppet and to said further poppet and arranged to drive said further poppet in a further direction such that when fluid passing through said further opening in said valve body exerts a force on said further poppet that is less than said further spring force, a further portion of said outer surface of said further poppet blocks said further channel and prevents said fluid from flowing from said further opening in said valve body into said further channel, and when said fluid exerts a force on said further poppet that is greater than said further spring force, said further portion of said outer surface of said further poppet is directed away from said further opening in said valve body to open said further channel and permit said fluid to flow from said further opening in said valve body through said further channel, said at least one opening in said further poppet, said further passage in said further poppet, said further opening in said further poppet and said opening in said poppet to said opening of said valve body.

2. The valve of claim 1 wherein said portion of said outer surface of said poppet includes at least one fluted portion.

3. The valve of claim 1 wherein said poppet includes a further opening therein in proximity to said further opening in said valve body; and said passage connects said opening and said further opening in said poppet.

4. The valve of claim 1 wherein said further portion of said outer surface of said poppet includes a tapered region, and said further portion of said passage wall of said valve body surrounds a narrowed portion of said passage.

5. The valve of claim 1 wherein said poppet includes an inwardly directed projection, and an end of said spring abuts said inwardly directed projection.

6. The valve of claim 5 further comprising a valve seat disposed in said passage of said poppet between said inwardly directed projection and said further poppet.

7. The valve of claim 6 wherein said further portion of said outer surface of said further poppet and said valve seat are configured such that when said fluid passing through said further opening in said valve body exerts a force on said further poppet that is less than said further spring force, said further portion of said outer surface of said further poppet contacts said valve seat.

8. The valve of claim 1 wherein said further portion of said outer surface of said further poppet comprises a tapered region.

9. The valve of claim 1 further comprising an adapter disposed in said passage of said valve body in proximity to said further opening in said valve body, and another end of said spring abuts a ledge formed in said adapter.

10. The valve of claim 1 wherein said passage wall of said poppet includes a ledge adjacent to said opening in said poppet, and an end of said further spring abuts said ledge.

11. The valve of claim 1 wherein said spring and said poppet are arranged such that when said fluid passing through said opening in said valve body exerts a force on said poppet that is less than said spring force, said poppet is driven toward said opening in said valve body, and when said fluid passing through said opening in said valve body exerts a force on said poppet that is greater than said spring force, said poppet is driven away from said opening in said valve body.

12. The valve of claim 1 wherein said further spring and said further poppet are arranged such that when said fluid passing through said further opening in said valve body exerts a force on said further poppet that is less than said further spring force, said further poppet is driven toward said further opening in said valve body, and when said fluid passing through said further opening in said valve body exerts a force on said further poppet that is greater than said further spring force, said further poppet is driven away from said further opening in said valve body.

13. A method of bidirectionally controlling movement of fluid, said method valve comprising the steps of:

providing a valve body having at least an opening and a further opening therein and having a passage connecting said opening and said further opening;

5 disposing a poppet within said passage of said valve body and arranging said poppet such that at least a portion of an outer surface of said poppet and at least a portion of a wall of said passage of said valve body define at least one channel; said poppet having at least an opening therein in proximity to said opening in said valve body and a passage connecting to said opening in said poppet;

10 coupling a spring to said poppet to drive said poppet in a direction such that when fluid passing through said opening in said valve body exerts a force on said poppet that is less than said spring force, a further portion of said outer surface of said poppet contacts a further portion of said passage wall of said valve body and prevents said fluid from flowing from said opening in said valve body into said channel, and when said fluid exerts a force on said poppet that is greater
15 than said spring force, said poppet is directed away from said further portion of said passage wall and permits said fluid to flow from said opening in said valve body through said channel and to said further opening in said valve body;

20 disposing a further poppet within said passage formed in said first mentioned poppet and arranging said further poppet such that at least a portion of an outer surface of said further poppet and at least a portion of a passage wall of said poppet define at least one further channel; said outer surface of said further poppet having at least an opening therein that connects to a passage formed within said further poppet; said passage within said further poppet connecting to a further opening in said further poppet that is in proximity to said opening in said poppet; and

25 coupling a further spring to said poppet and to said further poppet to drive said further poppet in a further direction such that when fluid passing through said further opening in said valve body exerts a force on said further poppet that is less than said further spring force, a

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30 further portion of said outer surface of said further poppet blocks said further channel and prevents said fluid from flowing from said further opening in said valve body into said further channel, and when said fluid exerts a force on said further poppet that is greater than said further spring force, said further portion of said outer surface of said further poppet is directed away from said further opening in said valve body to open said further channel and permit said fluid to flow from said further opening in said valve body through said further channel, at least one said opening in said further poppet, said further passage in said further poppet, said further opening in said further poppet and said opening in said poppet to said opening of said valve body.

14. A hydraulic apparatus, comprising:

at least one supply line;

at least one return line;

a pump configured to drive fluid through said supply line at a supply pressure;

5 a flow component disposed between said supply line and said return line and providing a pressure differential in the fluid such that a fluid pressure in the return line is less than the supply pressure; and

a bidirectional check valve disposed within at least one of said supply line said return line;

10 said bidirectional check valve comprising:

a valve body having at least an opening and a further opening therein and having a passage connecting said opening and said further opening;

a poppet disposed within said passage of said valve body and arranged such that at

least a portion of an outer surface of said poppet and at least a portion of a wall of said passage of
15 said valve body define at least one channel; said poppet having at least an opening therein in
proximity to said opening in said valve body and a passage connecting to said opening in said
poppet;

a spring coupled to said poppet and arranged to drive said poppet in a direction
such that when fluid passing through said opening in said valve body exerts a force on said
20 poppet that is less than said spring force, a further portion of said outer surface of said poppet
contacts a further portion of said passage wall of said valve body and prevents said fluid from
flowing from said opening in said valve body into said channel, and when said fluid exerts a
force on said poppet that is greater than said spring force, said poppet is directed away from said
further portion of said passage wall and permits said fluid to flow from said opening in said valve
25 body through said channel and to said further opening in said valve body;

a further poppet disposed within said passage formed in said first mentioned
poppet and arranged such that at least a portion of an outer surface of said further poppet and at
least a portion of a passage wall of said poppet define at least one further channel; said outer
surface of said further poppet having at least an opening therein that connects to a passage
30 formed within said further poppet, said passage within said further poppet connecting to a further
opening in said further poppet that is in proximity to said opening in said poppet; and

a further spring coupled to said poppet and to said further poppet and arranged to
drive said further poppet in a further direction such that when fluid passing through said further
opening in said valve body exerts a force on said further poppet that is less than said further
35 spring force, a further portion of said outer surface of said further poppet contacts a further

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portion of said passage wall of said poppet and prevents said fluid from flowing from said further opening in said valve body into said further channel, and when said fluid exerts a force on said further poppet that is greater than said further spring force, said further portion of said outer surface of said further poppet is directed away from said further portion of said wall of said poppet and permits said fluid to flow from said further opening in said valve body through said further channel, said at least one opening in said further poppet, said further passage in said further poppet, said further opening in said further poppet and said opening in said poppet to said opening of said valve body.

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